Peri-Urban Rangeland Land Productivity Monitoring and Evaluation

Baseline Report

DRAFT September 22, 2013

USDA-ARS Jornada Experimental Range

Las Cruces, NM USA

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Project Background and Objectives:

As stated in the "Terms of Reference Peri-Urban Rangeland Land Productivity Monitoring and Evaluation, Wave 2":

Summary

MCA-Mongolia has a bona fide need to develop and implement a rangeland health monitoring and assessment program to measure impacts of the Peri-Urban Rangeland Project (PURP) on rangeland health and rangeland environmental degradation in Mongolia's peri-urban regions. In the peri-urban pasture lands near urban centers in Mongolia, the country's tradition of open access pasture use, combined with an influx of migrants' herds, has led to overgrazing and environmental degradation. In response, PURP aims to improve livestock management, productivity, and, ultimately, farm income in the peri-urban pasture land areas through a system of leases to herder groups. PURP will provide herder groups with key infrastructure and training to improve skills in pasture land management including stock density and monitoring pasture land carrying capacity. Currently, approximately 387 serviced tracts of pasture land between approximately 500-1500 hectares (grass-fed livestock system) and 100 hectares (intensive system) are being identified for approximately 15 year length project leases.

As part of monitoring and evaluation activities, the Millennium Challenge Corporation (MCC) and Millennium Challenge Account-Mongolia (MCA-M) will carry out an impact evaluation that examines how the securing of long-term land use rights and provision of infrastructure and training through PURP affects not just livestock herding efficiency and productivity, but also environmental degradation and rangeland quality in peri-urban areas. In support of the rangeland quality component of the evaluation, MCC has signed an agreement with the United States Department of Agriculture (USDA). Under this agreement, USDA will provide technical advice and support to MCC regarding the monitoring and evaluation of pastureland and oversee a local land quality contractor that will carry out evaluation activities including the collection of baseline and follow-up data, as well as the training of local officials in sustainable land quality monitoring.

The local land quality contractor chosen to perform these tasks is USDA's partner organization, the Mongolian Society for Rangeland Management (MSRM). This TOR outlines the tasks that MSRM will complete as part of monitoring and evaluation activities. This includes applying USDA methodology of rangeland health monitoring that has been adapted for the Mongolian context to capture core indicators of rangeland health. MSRM will be responsible for selecting a spatially-unbiased representative sample of monitoring points that can be used to make

statistically-defensible statements about PURP impacts on rangeland quality. MSRM will also utilize cages to capture land productivity measures. Throughout all of these tasks, the firm will be overseen and managed by the MCA-M Monitoring and Evaluation unit and with technical assistance and guidance from UDSA, MCC and its associate contractor Innovations for Poverty Action (IPA).

Background

Millennium Challenge Corporation (MCC)

The Government of Mongolia has received grant funding of approximately US$ 285.0 million from the United States of America, acting through the Millennium Challenge Corporation (MCC), to enable the Government of Mongolia to implement a "Compact" to achieve key objectives in the areas of economic growth and poverty reduction. The Government of Mongolia has established a special entity, MCA-Mongolia, to implement the Compact on its behalf. Implementation began in September of 2008 and will continue until September of 2013. This Statement of Work concerns the Peri-Urban Rangeland Project, one of six projects funded by the Compact.

MCA-Mongolia Peri-Urban Rangeland Project (PURP)

A steady stream of poor rural Mongolians are abandoning traditional nomadic herding practices and migrating to the cities in search of better lives. In peri-urban pasture lands near urban centers, Mongolia's tradition of open access pasture use, combined with the influx of migrants' herds, has led to overgrazing and triggered interest in new land-use regimes that will encourage investment, improved land use, and higher agricultural productivity.

Mongolia's pasture lands are owned by the state. Peri-Urban Rangeland Project, or PURP, will introduce a system of leasing peri-urban pasture lands to herder groups, and provide key infrastructure and training to improve rangeland and livestock management, productivity and, ultimately, farm income. These peri-urban areas include 57 soums and districts located in five aimags and one city as follows:

- Peri-Urban Ulaanbaatar, defined as pasture land within the boundaries of the Ulaanbaatar region, plus pasture land located in Tuv aimag that is within approximately 30 kilometers of the Ulaanbaatar-Tuv border, specifically the soums of Erdene, Sergelen, Altanbulag, Argalant, Bayanchandmani, Batsumber, Bornuur, Mungunmort, Bayan, Arkhust, Bayanjargalan, Bayandelger and Bayantsogt.
- Peri-Urban Darkhan, defined as pasture land within the boundaries of Darkhan-Uul aimag, plus pasture land located in Selenge aimag that is within approximately 30 kilometers of the Darkhan-Uul-Selenge border, specifically the soums of Khushaat, Zuunburen, Javkhlant, Eruu Mandal, Bayangol, Saikhan, Shaamar, and Orkhon.
- Peri-Urban Erdenet, defined as pasture land within the boundaries of Orkhon aimag (Erdenet), plus pasture land located in Bulgan aimag that is within approximately 30 kilometers of the Orkhon-Bulgan border, specifically the soums of Bugat, Khangal, Selenge, Orkhon, Buregkhangai, and the soums of Baruunburen and Orkhontuul in Selenge aimag.
- Peri-urban Choibalsan, defined as pasture land within the boundaries of the Kherlen soum surrounding the Choibalsan city, plus that rangeland located in soums of Dornod aimag that is within approximately 45 kilometers of the Kherlen soum border, specifically Bayantumen, Bulgan, Sergelen, Choibalsan soums.
- Peri-urban Kharkhorin, defined as pasture land within the boundaries of Kharkhorin soum, plus that rangeland in Burd, Zuil, Khujirt, Ulziit, Zuunbayan-Ulaan, Taragt, Arvaikheer soums of the Uvurkhangai aimag and Khotont and Tuvshruuleh soums of the Arkhangai aimag.

The project is being implemented first in the peri-urban areas of Ulaanbaatar, Darkhan, and Erdenet, with herder groups currently signing leases. Planning for implementation of the project in the expansion sites of Choibolson and Kharkhorin is currently underway.

Specifically, PURP entails the following:

(i) strengthening of the legal framework and environment for pastureland management and long term leasing of peri-urban pastureland to herders;

(ii) identification of suitable sites (tracts of pasture land) for leasing in each peri-urban area;

(iii) selection of up to 465 herder groups to receive 15-year leases to the tracts of pasture land;

(iv) installation of wells and supplying of materials for construction of fences and animal shelters on the leased pasture land;

(v) training of herder groups to improve their understanding of leasehold rights and responsibilities, and to improve their skills in pasture land management, herd productivity, and business and marketing. This training will include stock density management, monitoring pasture land carrying capacity, well operation and maintenance, capturing precipitation run-off, fodder/feed storage techniques,

proper animal health and vet services, and business and marketing plans. Also, local land and agricultural officials will receive training on their related responsibilities; and

(vi) identification and management of environmental, social, health and safety impacts, consistent with MCC Environmental Guidelines, MCC Gender Policy and the World Bank Operational Policy on Involuntary Resettlement (O.P. 4.12).

Herder groups who receive leases under the PURP will engage in either intensive farming, which focuses on dairy farming and uses more fodder and commercially produced feed, or semi-intensive farming, which keeps to more traditional livestock patterns and uses largely hay for feed. In Ulaanbaatar, Darkhan and Erdenet, approximately 30% of farm sites will be intensive and the rest semi-intensive. In the smaller peri-urban areas of Kharkhorin and Choibalsan, almost all farm-sites will be semi-intensive.

Semi-intensive farms will be larger than intensive farms because of their greater dependence on grazing. Based on the grass yield required for 300 sheep units per household, the amount of pastureland needed for a semi-intensive farm is at least 170 hectares (ha) per household for Darkhan and Erdenet and at least 200 ha per household for Ulaanbaatar. For intensive farms, the minimum area required is about 90 ha per household for Darkhan and Erdenet and 100 ha per household in Ulaanbaatar. Combining this per-household pasture requirement with the variable number of households in a herder group (2-6) will result in semi-intensive farms ranging from 340-2,400 ha and intensive farms ranging from 180-900 ha.

Since a key project objective is sustainable livestock farming, and since Mongolia's peri-urban pasture lands are generally highly degraded, herder groups participating in the project will have to limit their animal numbers to the land's carrying capacity and will receive training on improving land management. It is expected that these measures will stop the degradation and lead to a gradual improvement in pasture land environmental conditions.

Monitoring and Evaluation

In order to assess this expectation, MCC and MCA-M will carry out an impact evaluation that examines whether and how the Project's activities affect livestock herding efficiency and productivity, as well as environmental degradation and rangeland quality in peri-urban areas.

The evaluation will include a special component, a baseline and monitoring effort of Project effects on land degradation, as well as training of local soum officials to sustainably monitor the rangeland after the Compact. This component will examine the Project's impacts on a variety of other direct measures that reflect rangeland health such as grass yields, carrying capacity of rangeland and rangeland quality as measured by the state of soil, vegetation composition, biomass production, hydraulic function, erosion, and potentially forest degradation. To the extent feasible, many of the indicators to be used for evaluation purposes will be designed and collected in a way that will be usable by the Government of Mongolia over the long-term and coordinated with the ongoing effort funded by the Swiss Government (SDC) with Hydro-Meteorological Institute (HMI).

In support of this component of the evaluation, MCC has signed a memorandum of understanding with the United States Department of Agriculture (USDA). Under this agreement, USDA will provide technical advice and support to MCC regarding the monitoring and evaluation of pastureland. This will include oversight of the local land quality contractor that is tasked with carrying out evaluation activities including the collection of baseline and follow-up data and the training of local officials. The local land quality contractor that has been chosen to perform these tasks is the USDA partner organization, the Mongolian Society for Rangeland Management (MSRM).

Impact Evaluation Design

The Project, in its two phases, was conducted with two kinds of impact evaluation design. The first phase in the main UB, Darkhan and Erdenet peri-urban areas saw Propensity Score Matching whereas the second phase in Choibalsan and Kharkhorin areas had a full Randomized Admissions. The design encompassed a two stage randomized selection process to determine which herder groups will receive the leasing slots that are available for the project. In the first stage of the design, all herder groups located in areas deemed fit for the project were allowed to submit applications for the available slots. These applications are cleared as meeting environmental and social assessment criteria and are scored by local selection committees, according to a set of predefined criteria. Those that pass this stage were short-listed for the second stage of selection. In the second stage of selection, the lease slots were randomly assigned to the short-listed candidates. Some candidates will be randomly selected to receive a leasing slot (the treatment group) while other candidates will not (the control group). Random assignment led to the creation of two virtually identical groups at the baseline. The only difference was that the treatment group was offered the lease and other associated project assistance while the other group (the control group) was not. As a result, any changes observed

between the two groups over time can be attributed to the project. The PURLS Survey has been used to collect data on the behavior and characteristics of herder groups in both the treatment and control groups. The outcomes of the herder households in the treatment and control group will be compared to assess the impacts of the program.

In the original project areas (Ulaanbaatar, Darkhan, and Erdenet peri-urban areas), it has been determined that a randomized evaluation is not feasible, given the low numbers of herder groups that meet environmental and social assessment criteria. Therefore a propensity score matching was made. In the expansion areas (Choibalsan and Kharkhorin), a randomized evaluation has been done.

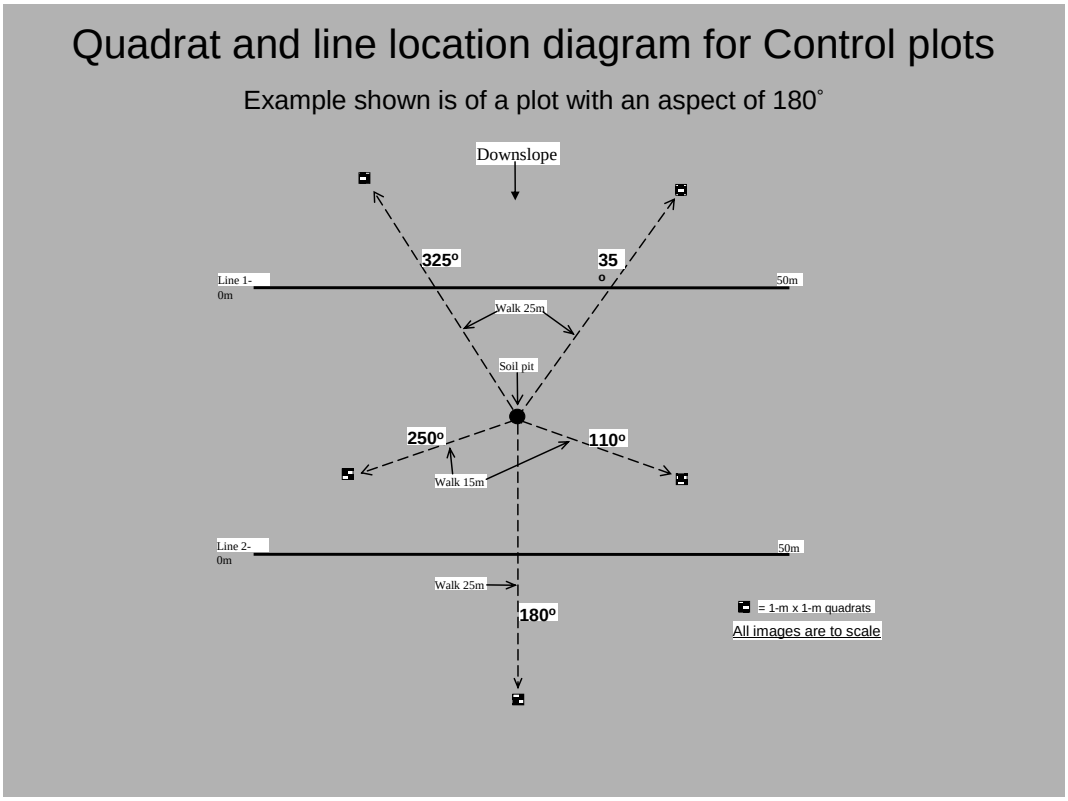
Objectives of the TOR

In cooperation with MCC and USDA, MCA-Mongolia has enlisted MSRM to collect data on rangeland environmental health and degradation. MCA-Mongolia will be the contracting party with MSRM and will provide day-to-day management and supervision. In addition, MCA-M will ask MSRM to work in collaboration with and under the supervision of a team of impact evaluation experts and economists from Innovations for Poverty Action (IPA). IPA was contracted by MCC in September 2008 to design and implement impact evaluations for some activities of the Mongolia program. IPA is based in the United States, but at least one member from IPA will be based in Mongolia for the period of the Contractor's activities, and will work closely with the Contractor to assure that the data collection is of the highest possible quality. MSRM will report to MCA, which will be liaising and coordinating between and making sure MCC and IPA agree that technical specifications/conditions have been met.

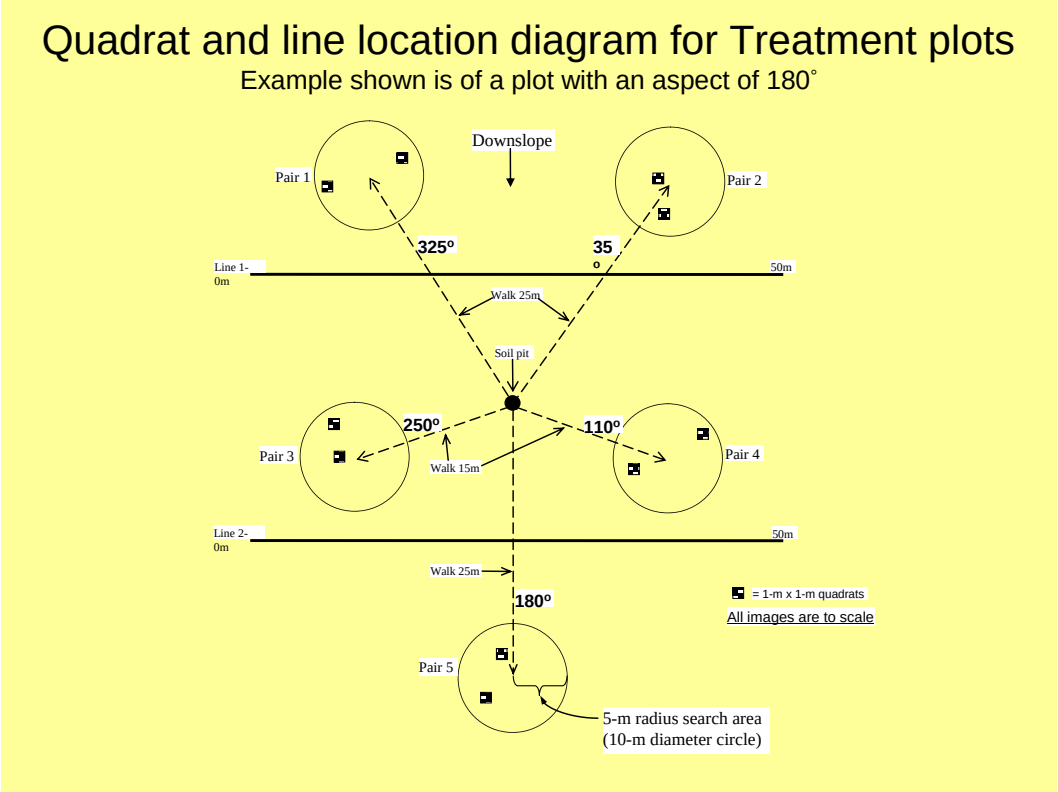
Design:

In May 2012, the Jornada Experimental Range selected the 6 best-matched Treatment-Control pairs from each of the 3 peri-urban areas (Erdenet, Darkhan and Ulaanbaatar) in 2011. Between April 22nd and May 2nd, MSRM installed the new fences at the 18 Treatment sites from Phase 1. On May 4th, two teams selected sites and installed fencing in the Kharkhorin and Choibalson areas for Phase II.

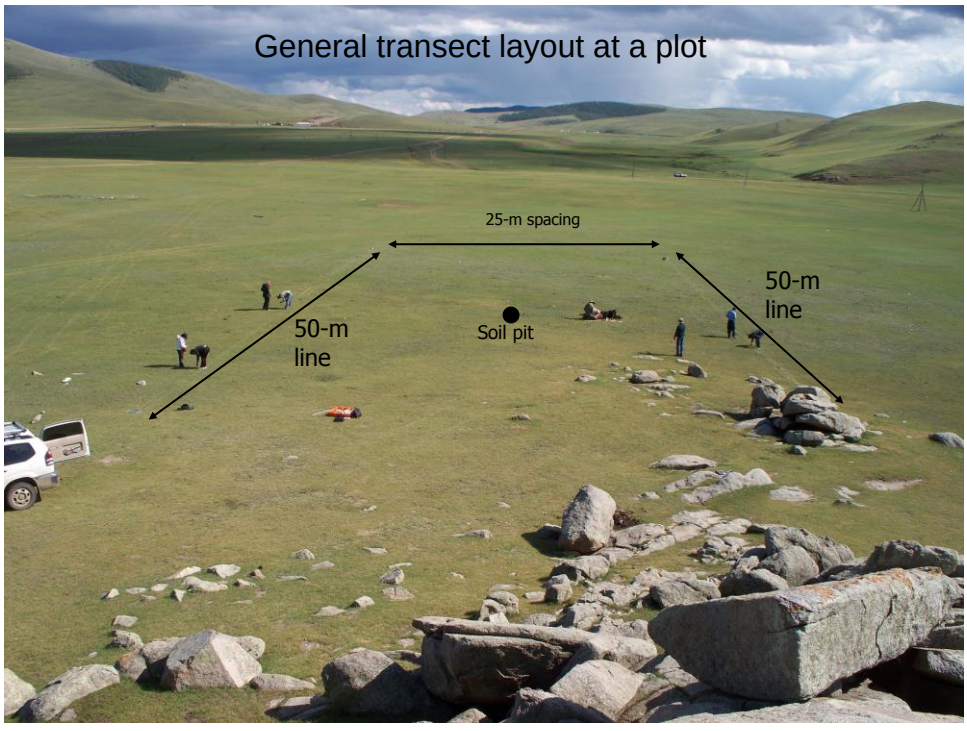
For a Control plot, the site characterization team marked the corners of five 1-m x 1-m quadrats in defined directions (relative to aspect at each site). Vegetation in half of every quadrat was clipped in Fall 2012, and the other half was clipped in Spring 2013. See example below of the Control plot design.



For a Treatment plot, the fencing team installed 5 2-m x 2-m fences (cages) and their paired unfenced control quadrats after the site characterization team completed their work. Fenced and unfenced quadrats were installed in the same relative locations at the site as Controls plots. Two 1-m x 1-m quadrats were chosen within each 10-m diameter circle, and were matched as closely as possible by percent perennial plant basal cover. One of the two quadrats was randomly chosen to be fenced. Each fence protects a 1-m x 1-m quadrat from livestock grazing. Vegetation in half of this quadrat was clipped in Fall 2012, and the other half was clipped in Spring 2013. See example below of the Treatment plot design.



At each site, two 50-m, parallel transects were installed and vegetation characteristics measured using the Line-point Intercept method.



Data Collection Methods:

Data were collected using Line-point Intercept method (Herrick, J. E., Van Zee, J. W., Havstad, K. M., Burkett, L. M., & Whitford, W. G. (2005). *Monitoring manual for grassland, shrubland and savanna ecosystems. Vol. I: Quick start*. USDA-ARS Jornada Experimental Range, Las Cruces, NM: Distributed by University of Arizona Press.) and Plant Production method (Herrick, J. E., Van Zee, J. W., Havstad, K. M., Burkett, L. M., & Whitford, W. G. (2005). *Monitoring manual for grassland, shrubland and savanna ecosystems. Vol. II: Design, supplementary methods and interpretation*. USDA-ARS Jornada Experimental Range, Las Cruces, NM: Distributed by University of Arizona Press.). The Plant Production method varied from the standard method in that all plants were clipped at 1-cm height above the soil surface, except shrubs and sub-shrubs (see #1 below). Nine plant functional groups were clipped on each 50-cm x 100-cm quadrat. The nine plant functional groups are defined below:

All shrub species + All sub-shrub species (no *Artemisia* species). Only leaves plus last year's woody growth (i.e., terminal nodes that grew last year) was clipped. Older woody material was not removed.

All *Potentilla* species combined.

Artemisia frigida **only**.

All other *Artemisia* species combined.

All remaining forb species combined.

All *Stipa* species combined.

All other grass species combined.

All *Carex* species combined.

All annual plant species combined.

Data Collection Schedule:

Timeline:

June 6 - 21, 2011 Collected Soil Characterization data for Phase I

June 7 - 19, 2011 Collected Line-point Intercept data for Phase I

May 3 - 21, 2012 Collected Soil Characterization data for Phase II

August 15 to September 9, 2012 Collected Line-point Intercept data for Phase II

Fall 2012 Collected Production data:

August 14 - 26, 2012 for Phase I

August 15 to September 9, 2012 for Phase II

Spring 2013 Collected Production data from April 16 to May 12, 2013

See DIMA (Database for Inventory Monitoring and Assessment) for exact collection dates. All MCC data are stored in DIMA on the Jornada server (R:\USDA\Soils\Data\Mongolia).

Line-Point Intercept (LPI = Cover): Analysis and Results

The data set is an LPI report exported from DIMA and has three response variables: bare soil, basal cover, and total foliar cover. The data set contains no missing data.

Within each of the 5 areas, between 5 and 9 Soums were sampled. Within each Soum, between 1 and 8 plots were sampled. Each treatment plot is paired spatially with a specific control plot. One of the objectives of the analysis is to determine how successful this pairing was.

There was one set treatment/control plots that did not pair correctly. It appears in the table below. Justin Van Zee investigated and determined that this set of plots is very close to the Uvurkhangai Kharkhorin/ Arkhangai Tuvshruulekh border and was actually intended to be paired. We decided to consider the Soum for both plots to be Uvurkhangai Kharkhorin.

Area	Soum	Plot	Treatment	Indicator	Average
Western	Uvurkhangai Kharkhorin	WC2-1	control	Bare Soil	0.178
Western	Uvurkhangai Kharkhorin	WC2-1	control	Basal Cover	0.025
Western	Uvurkhangai Kharkhorin	WC2-1	control	Total Foliar	0.768
Western	Arkhangai Tuvshruulekh	WT2-1	treatment	Bare Soil	0.133
Western	Arkhangai Tuvshruulekh	WT2-1	treatment	Basal Cover	0.185
Western	Arkhangai Tuvshruulekh	WT2-1	treatment	Total Foliar	0.848

The table below indicates the number of plots for each Area*Soum*Treatment combination after the change described above.

Area	Soum	Control_n	Treatment_n
Darkhan	DA-Hongor	2	2
Darkhan	DA-Orhon	1	1
Darkhan	SE-Bayangol	3	3
Darkhan	SE-Hushaat	4	4
Darkhan	SE-Javhlant	2	2
Darkhan	SE-Saihan	1	1
Darkhan	SE-Shaamar	1	1
Darkhan	SE-Zuunburen	1	1
Dornod	Dornod Bayantumen	6	6
Dornod	Dornod Bulgan	8	8
Dornod	Dornod Choibalsan	3	3
Dornod	Dornod Intensive	1	1
Dornod	Dornod Sergelen	1	1
Erdenet	BU-Bugat	3	3
Erdenet	BU-Hangal	1	1
Erdenet	OR-Bayan-Undur	5	5
Erdenet	OR-Jargalant	5	5
Erdenet	SE-Orhontuul	1	1
Ulaanbaatar	TU-Altanbulag	2	2
Ulaanbaatar	TU-Argalant	1	1
Ulaanbaatar	TU-Bayan	2	2
Ulaanbaatar	TU-Bayanchandmani	3	3
Ulaanbaatar	TU-Bayandelger	2	2
Ulaanbaatar	TU-Bayantsogt	2	2
Ulaanbaatar	TU-Erdene	2	2
Ulaanbaatar	TU-Sergelen	3	3
Western	Arkhangai Khotont	4	4
Western	Arkhangai Tuvshruulekh	3	3
Western	Uvurkhangai Burd	2	2
Western	Uvurkhangai Kharkhorin	3	3
Western	Uvurkhangai Khujirt	3	3
Western	Uvurkhangai Taragt	6	6
Western	Uvurkhangai Ulziit	1	1
Western	Uvurkhangai Yusunzuil	3	3
Western	Uvurkhangai Zuunbayan-Ula	6	6

There are two sets of boxplots of the raw data in PDF files (available on request). "LPI data by Soum.pdf" groups the data by Area*Soum*Treatment combinations, while "LPI data by Area.pdf" groups the data by Area*Treatment combinations. The plots show that the bare soil values for the SE-Orhontuul soum in the Erdenet area are outliers.

Raw statistics at the level of each Soum are shown in the "LPI_raw_stats" sheet in the file "LPI Summary.xlsx" (available on request).

Analysis of Variance was conducted separately for each Area. It was carried out in four ways:

(1) Independent plots, without regard to Soum or pairing

(2) Independent Soums without regard to pairing, with plots within each Soum considered as subsamples

(3) Paired independent plots without regard to Soum

(4) Independent Soums with paired plots nested within them

The table below has p-values for each analysis resulting from the test of equal means between treatment and control groups.

Indicator	Area	P-value			
		Analysis1	Analysis2	Analysis3	Analysis4
Bare Soil	Darkhan	0.990	0.987	0.967	0.967
Bare Soil	Dornod	0.337	0.283	0.338	0.283
Bare Soil	Erdenet	0.965	0.940	0.924	0.924
Bare Soil	Ulaanbaatar	0.848	0.767	0.767	0.767
Bare Soil	Western	0.656	0.623	0.610	0.610
Basal Cover	Darkhan	0.762	0.561	0.487	0.487
Basal Cover	Dornod	0.563	0.441	0.519	0.441
Basal Cover	Erdenet	0.882	0.847	0.783	0.783
Basal Cover	Ulaanbaatar	0.950	0.929	0.925	0.925
Basal Cover	Western	0.143	0.073	0.090	0.073
Total Foliar	Darkhan	0.646	0.490	0.033	0.033
Total Foliar	Dornod	0.279	0.232	0.251	0.232
Total Foliar	Erdenet	0.910	0.845	0.806	0.806
Total Foliar	Ulaanbaatar	0.499	0.434	0.267	0.267
Total Foliar	Western	0.629	0.567	0.481	0.481

Although Analysis 4 appears to have the most power, pairing the plots changes the results of the analysis in no more than 2 of the 15 cases, depending on the reference analysis and chosen alpha level.

Estimates of treatment least squares means for each analysis are in the "LPI_lsmeans" sheet in the file "LPI Summary.xlsx" (available on request).

Line-Point Intercept (LPI = Cover): Discussion

The analyses demonstrated that there was no systematic bias in either the Phase I areas (for which we used a matched-pair approach for control selection) or the two expansion (Phase II) areas (for which we used the controls selected by IPA using a matched-pair approach). This analysis supports use of these plots for endline data collection for all five areas, recognizing that interpretation of results from the Phase I areas will be limited by both the small sample size, and the fact that the "controls" were necessarily (due to the lack of other control GPS information from the IPU) simply located in similar areas immediately adjacent to the treatments.

Biomass/Production: Analysis and Results

For this analysis, only total production was considered. For each plot*treatment combination, biomasses from the 9 possible functional groups in each of the 5 subplots were summed to obtain the total biomass. The study was conducted in 2 phases: Phase I and Phase II.

There is a greater level of short-term interest in this dataset than the cover by both the Mongolian Government (which is interested in using it for stocking rate estimates) and MCA/MCC (which

may wish to use it to help evaluate the extent to which the treatments were implemented as planned). Consequently, we have included more information, including some graphs, in the text of this section of the report. These interpretations will be made in cooperation with the Mongolian Government (stocking rate estimates), and MCA/IPA (implementation evaluation) during a planned December 2013 visit. Our discussion here is limited to the extent to which the baseline data demonstrate successful avoidance of bias in the experimental design.

Phase I

Phase I was conducted in 3 areas (Darkhan, Erdenet and Ulaanbaatar). Plots are nested within Herder Groups, which are nested within Soums, which are nested within Areas. At each plot, there were 3 treatments: uncaged treatment, uncaged control, and caged treatment. Cages went missing in some cases. The table below shows the Area*Soum*Herder Group*Year*Treatment combination for which we have data.

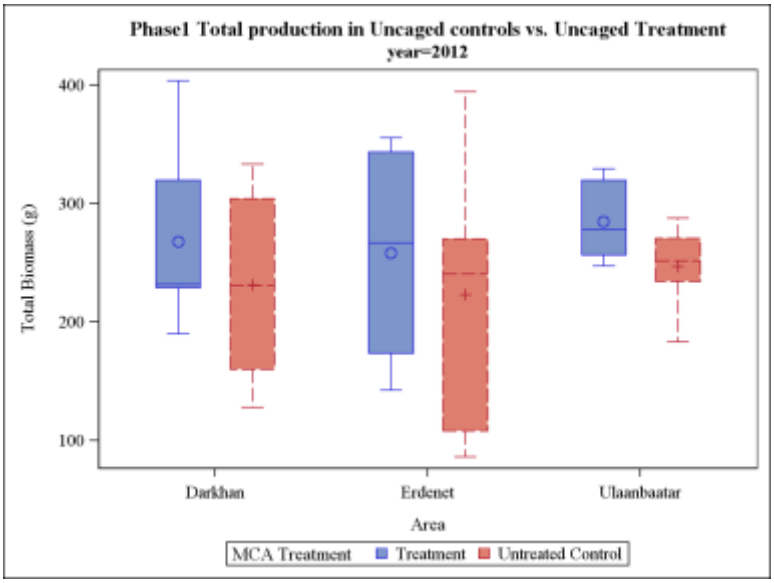
Area	Soum	Herder Group	2012			2013		
			uncaged treatment	uncaged control	caged treatment	uncaged treatment	uncaged control	caged treatment
Darkhan	Bayangol	DN 10-1 and DT 10-1	1	1	1	1	1	1
Darkhan	Hongor	DN 12-6 and DT 12-4	1	1	missing	1	1	missing
Darkhan	Javhlant	DN 3-2 and DT 3-6	1	1	1	1	1	1
Darkhan	Javhlant	DN 9-4 and DT 9-6	1	1	1	1	1	1
Darkhan	Orhon	DN 2-5 and DT 2-6	1	1	1	1	1	1
Darkhan	Saihan	DN 1-6 and DT 1-3	1	1	1	1	1	missing
Erdenet	Bayan-Undur	EN 2-2 and ET 2-6	1	1	1	1	1	1
Erdenet	Bayan-Undur	EN 9-3 and ET 9-2	1	1	1	1	1	missing
Erdenet	Bugat	EN 15-1 and ET 15-3	1	1	1	1	1	1
Erdenet	Jargalant	EN 5-6 and ET 5-5	1	1	1	1	1	1
Erdenet	Jargalant	EN 20-1 and ET 20-3	1	1	1	1	1	1
Erdenet	Orhontuul	EN 3-4 and ET 3-3	1	1	1	1	1	missing
Ulaanbaatar	Altanbulag	UN 20-3 and UT 20-6	1	1	1	1	1	1
Ulaanbaatar	Bayan	UN 17-3 and UT 17-1	1	1	1	1	1	1
Ulaanbaatar	Bayanchandmani	UN 10-1 and UT 10-1	1	1	1	1	1	1
Ulaanbaatar	Bayantsogt	UN 2-6 and UT 2-6	1	1	1	1	1	1
Ulaanbaatar	Erdene	UN 8-2 and UT 8-3	1	1	1	1	1	1
Ulaanbaatar	Sergelen	UN 12-1 and UT 12-4	1	1	1	1	1	missing

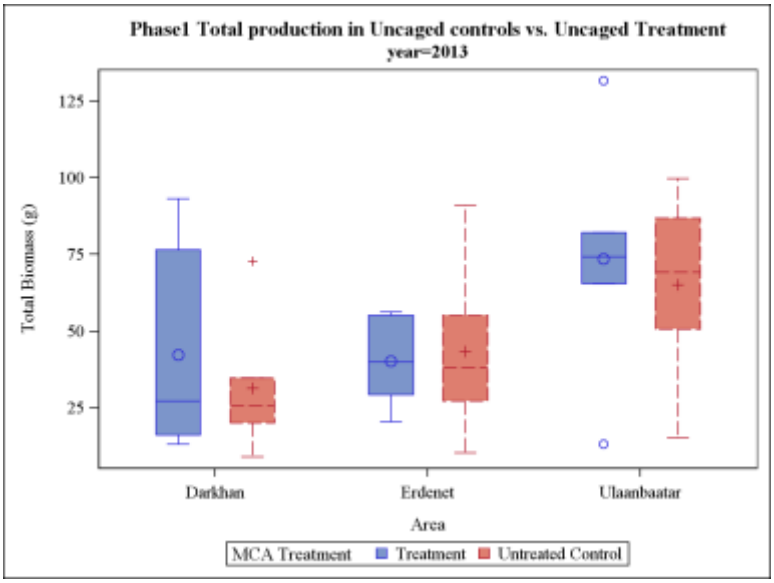
The analysis was conducted separately for each Area*Year combination. There are two objectives: (1) to compare uncaged treatments to uncaged controls, and (2) to compare uncaged treatments to caged treatments. Only plots for which both groups are present will be used in the analysis.

Boxplots of the raw data are below, followed by analysis results:

First analysis: uncaged treatments vs. uncaged controls

For this comparison there are no plots with missing cages.

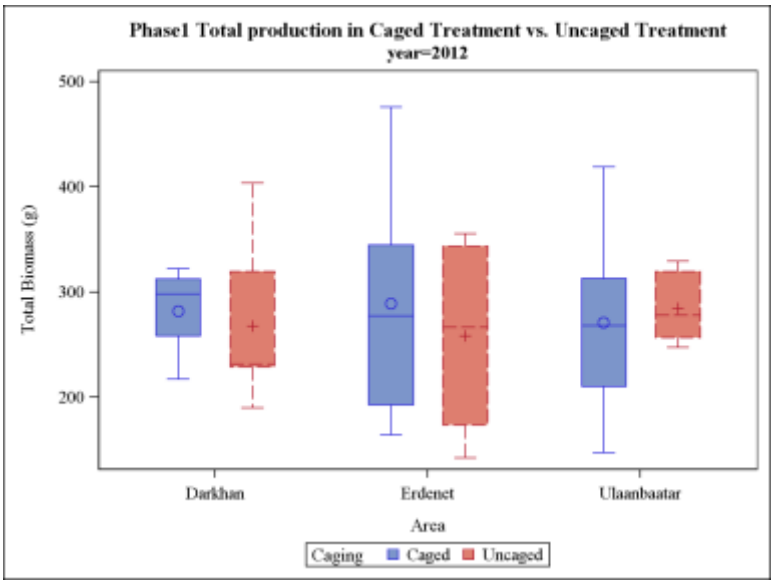


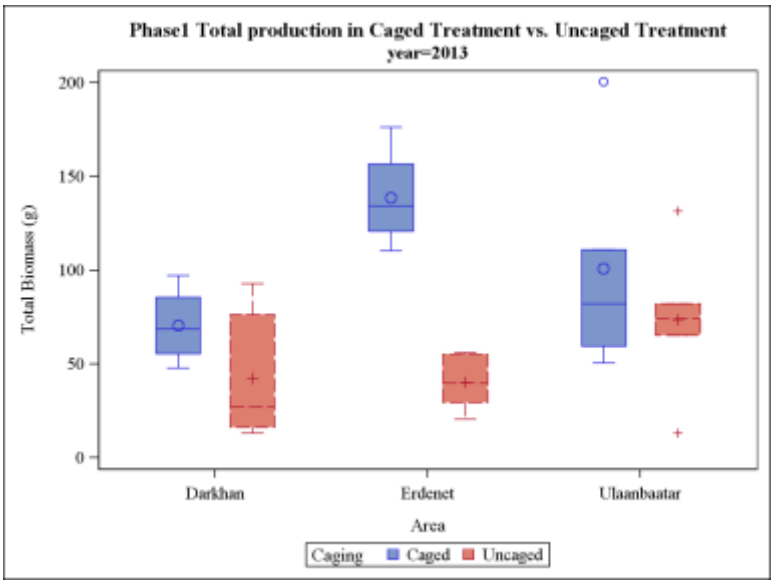


Area	Year	Uncaged Treatment LSMean	Uncaged Control LSMean	Standard Error	P-value
Darkhan	2012	267.83	231.27	32.36	0.443
Darkhan	2013	42.35	31.45	11.73	0.526
Erdenet	2012	258.21	223.42	41.96	0.571
Erdenet	2013	40.28	43.38	8.97	0.812
Ulaanbaatar	2012	284.92	246.82	14.61	0.095
Ulaanbaatar	2013	73.58	65.22	13.94	0.680

Second analysis: uncaged treatments vs. caged treatments

The two plots below show all of the data, including the 1 plot in 2012 and 5 plots in 2013 that have uncaged treatment data but no caged treatment data.





The analysis results below use all of the data. (Note that the least squares means for each group have unequal standard errors because of the unbalanced treatments.)

Area	Year	Caged Treatment LSMean	Caged Treatment Standard Error	Uncaged Treatment LSMean	Uncaged Treatment Standard Error	P-value
Darkhan	2012	281.90	29.40	267.83	26.83	0.732
Darkhan	2013	70.70	14.92	42.35	12.19	0.179
Erdenet	2012	288.95	43.46	258.21	43.46	0.628
Erdenet	2013	138.88	10.15	40.28	8.28	0.000
Ulaanbaatar	2012	271.17	28.63	284.92	28.63	0.741
Ulaanbaatar	2013	100.96	22.06	73.58	20.14	0.383

The results below use only plots for which caged treatment data exist. (Least squares means for each group have equal standard errors because of balance.)

Area	Year	Caged Treatment LSMean	Uncaged Treatment LSMean	Standard Error	P-value
Darkhan	2012	287.73	242.60	25.75	0.262
Darkhan	2013	70.70	21.10	8.09	0.005
Erdenet	2012	306.30	265.73	55.02	0.621
Erdenet	2013	138.88	44.33	10.86	0.001
Ulaanbaatar	2012	283.30	282.14	33.36	0.981
Ulaanbaatar	2013	100.96	71.84	23.35	0.404

Phase II

Phase II was carried out at two sites: Dornod and Western. It is somewhat similar to Phase I except that there was no uncaged control sampled at each plot. Instead, the uncaged control was sampled in a different herder group.

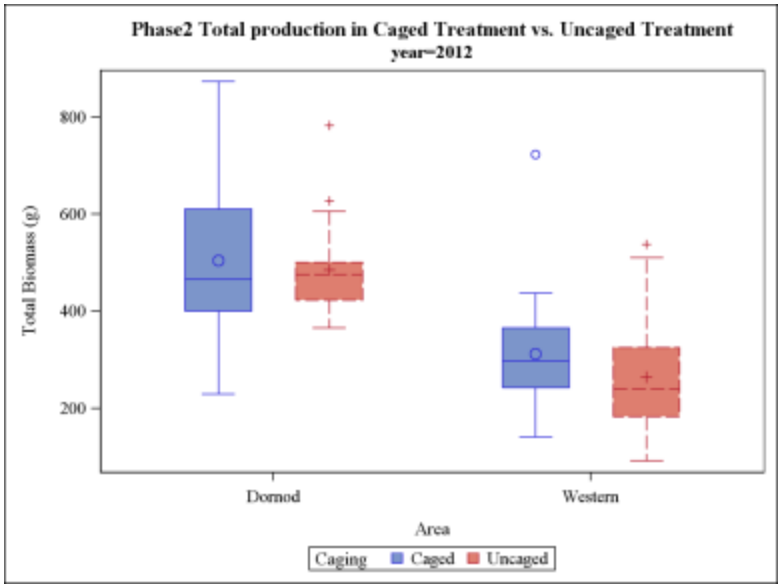
The comparison of uncaged treatments to caged treatments is the same as in Phase I. Like in Phase I, in many cases the cages were missing and could not be sampled. The two tables below show the data present in the data set (they are separated by Area to fit on a single page):

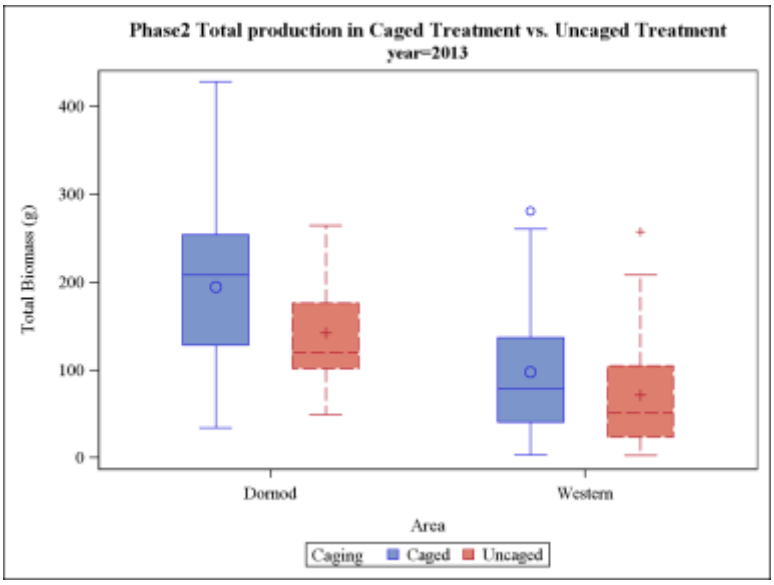
Area	Soum	Herder Group	2012		2013	
			caged treatment	uncaged treatment	caged treatment	uncaged treatment
Dornod	Bayantumen	DT 20-1	1	1	1	1
Dornod	Bayantumen	DT 11-1	1	1	1	1
Dornod	Bayantumen	DT 14-1	1	1	1	1
Dornod	Bayantumen	DT 5-1	1	1	1	1
Dornod	Bayantumen	DT 3-1	1	1	1	1
Dornod	Bayantumen	DT 17-2	missing	1	missing	1
Dornod	Bulgan	DT 15-1	1	1	1	1
Dornod	Bulgan	DT 16-1	1	1	1	1
Dornod	Bulgan	DT 4-1	1	1	1	1
Dornod	Bulgan	DT 9-3	missing	1	burned	burned
Dornod	Bulgan	DT 12-1	1	1	1	1
Dornod	Bulgan	DT 19-1	1	1	1	1
Dornod	Bulgan	DT 6-1	1	1	1	1
Dornod	Bulgan	DT 1-1	1	1	1	1
Dornod	Choibalsan	DT 2-1	1	1	1	1
Dornod	Choibalsan	DT 10-1	1	1	1	1
Dornod	Choibalsan	DT 18-1	1	1	1	1
Dornod	Intensive	DT 8-1	missing	1	missing	1
Dornod	Sergelen	DT 13-2	1	1	burned	burned

Notice that two sites burned. Those sites are not included in this analysis. However, they were actually sampled and had no production, so an alternative approach would be to set their total production to zero and re-run the analysis.

Area	Soum	Herder Group	2012		2013	
			caged treatment	uncaged treatment	caged treatment	uncaged treatment
Western	Burd	WT 25-1	1	1	1	1
Western	Burd	WT 28-1	1	1	1	1
Western	Kharkhorin	WT 12-1	1	1	1	1
Western	Kharkhorin	WT 2-1	1	1	1	1
Western	Kharkhorin	WT 4-1	1	1	1	1
Western	Khotont	WT 31-1	1	1	1	1
Western	Khotont	WT 18-1	1	1	1	1
Western	Khotont	WT 33-1	1	1	1	1
Western	Khotont	WT 23-1	1	1	1	1
Western	Khujirt	WT 6-1	1	1	1	1
Western	Khujirt	WT 1-2	1	1	missing	1
Western	Khujirt	WT 13-1	1	1	1	1
Western	Taragt	WT 20-1	1	1	1	1
Western	Taragt	WT 21-1	1	1	missing	1
Western	Taragt	WT 29-1	1	1	1	1
Western	Taragt	WT 10-1	1	1	1	1
Western	Taragt	WT 3-1	missing	1	missing	1
Western	Taragt	WT 9-1	1	1	1	1
Western	Tuvshruulekh	WT 15-1	1	1	missing	1
Western	Tuvshruulekh	WT 14-1	1	1	missing	1
Western	Tuvshruulekh	WT 27-1	1	1	missing	1
Western	Ulziit	WT 21-1	1	1	missing	1
Western	Yusunzuil	WT 8-1	1	1	1	1
Western	Yusunzuil	WT 7-1	1	1	1	1
Western	Yusunzuil	WT 30-1	1	1	1	1
Western	Zuunbayan-Ulaan	WT 22-1	1	1	missing	1
Western	Zuunbayan-Ulaan	WT 24-1	1	1	missing	1
Western	Zuunbayan-Ulaan	WT 5-1	1	1	1	1
Western	Zuunbayan-Ulaan	WT 11-1	1	1	missing	1
Western	Zuunbayan-Ulaan	WT 19-1	1	1	missing	1
Western	Zuunbayan-Ulaan	WT 16-1	1	1	1	1

The plots below use all data, including the uncaged treatments for which there are no caged treatment data.





As in Phase I, the analysis was run in two ways: first using all observations, and second using only plots at which both caged and uncaged treatments were sampled. Results are in the tables below:

The analysis results below use all of the data. (Note that the least squares means for each group have unequal standard errors because of the unbalanced treatments.)

Area	Year	Caged Treatment LSMean	Caged Treatment Standard Error	Uncaged Treatment LSMean	Uncaged Treatment Standard Error	P-value
Dornod	2012	504.68	32.26	485.07	29.61	0.657
Dornod	2013	194.75	21.33	142.35	20.03	0.083
Western	2012	311.46	20.18	264.05	19.85	0.099
Western	2013	97.74	15.41	71.56	12.37	0.191

The results below are from an analysis using only plots for which caged treatment data exist. Least squares means have equal standard errors for each group because of balance.

Area	Year	Caged Treatment LSMean	Uncaged Treatment LSMean	Standard Error	P-value
Dornod	2012	504.68	486.92	32.94	0.706
Dornod	2013	194.75	146.69	21.94	0.133
Western	2012	311.46	267.49	20.20	0.129
Western	2013	97.74	71.72	14.72	0.219

Phase II Uncaged Control Herder Groups vs. Uncaged Treatment Herder Groups

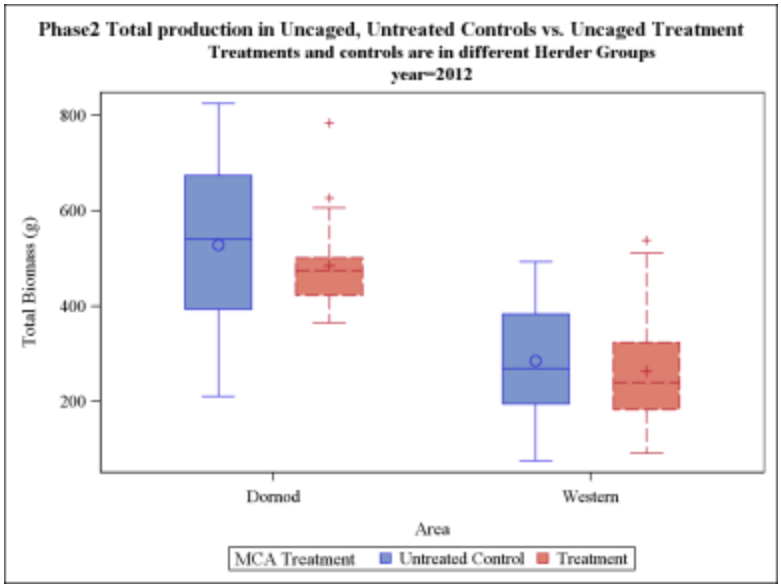
The second objective is to compare untreated "control" herder groups with the treated herder groups and to assess the effectiveness of pairing the herder groups. The tables below show the paired groups and the observations present in the data set. Because of their size, the tables are separated by area.

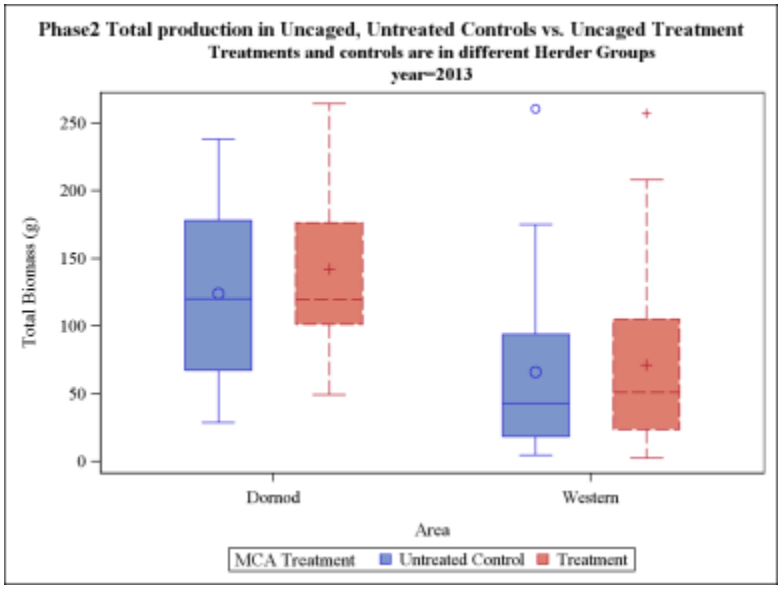
Area	Soum	Pairing code	Treatment Herder Group	Control Herder Group	2012		2013	
					Uncaged Treatment	Uncaged Control	Uncaged Treatment	Uncaged Control
Dornod	Bayantumen	11	DT 11-1	DC 11-1	1	1	1	1
Dornod	Bayantumen	14	DT 14-1	DC 14-2	1	1	1	1
Dornod	Bayantumen	17	DT 17-2	DC 17-1	1	1	1	1
Dornod	Bayantumen	20	DT 20-1	DC 20-1	1	1	1	1
Dornod	Bayantumen	3	DT 3-1	DC 3-1	1	1	1	1
Dornod	Bayantumen	5	DT 5-1	DC 5-1	1	1	1	1
Dornod	Bulgan	12	DT 12-1	DC 12-1	1	1	1	1
Dornod	Bulgan	15	DT 15-1	DC 15-1	1	1	1	1
Dornod	Bulgan	16	DT 16-1	DC 16-1	1	1	1	1
Dornod	Bulgan	19	DT 19-1	DC 19-2	1	1	1	1
Dornod	Bulgan	1	DT 1-1	DC 1-1	1	1	1	1
Dornod	Bulgan	4	DT 4-1	DC 4-1	1	1	1	1
Dornod	Bulgan	6	DT 6-1	DC 6-1	1	1	1	1
Dornod	Bulgan	9	DT 9-3	DC 9-1	1	1	missing	1
Dornod	Choibalsan	10	DT 10-1	DC 10-1	1	1	1	1
Dornod	Choibalsan	18	DT 18-1	DC 18-1	1	1	1	1
Dornod	Choibalsan	2	DT 2-1	DC 2-1	1	1	1	1
Dornod	Intensive	8	DT 8-1	DC 8-2	1	1	1	1
Dornod	Sergelen	13	DT 13-2	DC 13-1	1	1	missing	1

The two missing uncaged treatment plots in 2013 were burned. Because their production was 0, we could insert zeros for these observations and re-run the analysis.

Area	Soum	Pairing code	Treatment Herder Group	Control Herder Group	2012		2013	
					Uncaged Treatment	Uncaged Control	Uncaged Treatment	Uncaged Control
Western	Burd	25	WT 25-1	WC 25-1	1	1	1	1
Western	Burd	28	WT 28-1	WC 28-1	1	1	1	1
Western	Kharkhorin	12	WT 12-1	WC 12-1	1	1	1	1
Western	Kharkhorin	2	WT 2-1	WC 2-1	1	1	1	1
Western	Kharkhorin	4	WT 4-1	WC 4-1	1	1	1	1
Western	Khotont	18	WT 18-1	WC 18-2	1	1	1	1
Western	Khotont	23	WT 23-1	WC 23-2	1	1	1	1
Western	Khotont	31	WT 31-1	WC 31-1	1	1	1	1
Western	Khotont	33	WT 33-1	WC 33-2	1	1	1	1
Western	Khujirt	13	WT 13-1	WC 13-1	1	1	1	1
Western	Khujirt	1	WT 1-2	WC 1-1	1	1	1	1
Western	Khujirt	6	WT 6-1	WC 6-1	1	1	1	1
Western	Taragt	10	WT 10-1	WC 10-1	1	1	1	1
Western	Taragt	20	WT 20-1	WC 20-1	1	1	1	1
Western	Taragt	26	WT 26-1	WC 26-1	1	1	1	1
Western	Taragt	29	WT 29-1	WC 29-1	1	1	1	1
Western	Taragt	3	WT 3-1	WC 3-1	1	1	1	1
Western	Taragt	9	WT 9-1	WC 9-1	1	1	1	1
Western	Tuvshruulekh	14	WT 14-1	WC 14-2	1	1	1	1
Western	Tuvshruulekh	15	WT 15-1	WC 15-2	1	1	1	1
Western	Tuvshruulekh	27	WT 27-1	WC 27-2	1	1	1	1
Western	Ulziit	21	WT 21-1	WC 21-1	1	1	1	1
Western	Yusunzuil	30	WT 30-1	WC 30-1	1	1	1	1
Western	Yusunzuil	7	WT 7-1	WC 7-1	1	1	1	1
Western	Yusunzuil	8	WT 8-1	WC 8-1	1	1	1	1
Western	Zuunbayan-Ulaan	11	WT 11-1	WC 11-1	1	1	1	1
Western	Zuunbayan-Ulaan	16	WT 16-1	WC 16-1	1	1	1	1
Western	Zuunbayan-Ulaan	19	WT 19-1	WC 19-2	1	1	1	1
Western	Zuunbayan-Ulaan	22	WT 22-1	WC 22-1	1	1	1	1
Western	Zuunbayan-Ulaan	24	WT 24-1	WC 24-3	1	1	1	1
Western	Zuunbayan-Ulaan	5	WT 5-1	WC 5-1	1	1	1	1

Boxplots of the raw data appear below:





Analysis of Variance was conducted separately for each Area and year. (For Dornod in 2013, this analysis did not use the 2 pairs of plots whose uncaged treatments burned.) It was carried out in four ways:

(1) Independent plots, without regard to Soum or pairing

(2) Independent plots without regard to pairing, but accounting for a random Soum effect

(3) Paired independent plots without regard to Soum

(4) Independent Soums with paired plots

The tables below show estimates least squares means, standard errors and p-values. Within an area and year, standard errors are equal for both treatments and controls because of balance.

Model-Based Least Squares Means									
Area	Year	Analysis1		Analysis2		Analysis3		Analysis4	
		Uncaged Treatment Mean	Uncaged Control Mean	Uncaged Treatment Mean	Uncaged Control Mean	Uncaged Treatment Mean	Uncaged Control Mean	Uncaged Treatment Mean	Uncaged Control Mean
Dornod	2012	485.07	528.63	465.38	508.93	485.07	528.63	467.40	510.96
Dornod	2013	142.35	125.94	137.21	120.80	142.35	125.94	137.21	120.80
Western	2012	264.05	285.56	275.35	296.85	264.05	285.56	274.71	296.21
Western	2013	71.56	66.02	77.14	71.61	71.56	66.02	77.14	71.61

Model-Based Standard Errors of LSMeans					
Area	Year	Analysis1	Analysis2	Analysis3	Analysis4
Dornod	2012	32.29	44.40	32.29	44.69
Dornod	2013	15.60	20.94	15.60	20.93
Western	2012	20.92	28.74	20.92	28.56
Western	2013	11.11	17.80	11.11	17.80

P-values From F-Tests					
Area	Year	Analysis1	Analysis2	Analysis3	Analysis4
Dornod	2012	0.346	0.294	0.245	0.245
Dornod	2013	0.462	0.428	0.462	0.428
Western	2012	0.470	0.365	0.264	0.264
Western	2013	0.726	0.590	0.595	0.590

Pairing the herder groups seems to be increasing power but at this point there are no significant differences.

Biomass/Production: Discussion

The analyses, like those for the cover data, demonstrated that there was no systematic bias in either the Phase I areas (for which we used a matched-pair approach for control selection) or the two expansion (Phase II) areas (for which we used the controls selected by IPA using a matched-pair approach). This analysis supports use of these plots for endline data collection for all five areas, recognizing that interpretation of results from the Phase I areas will be limited by both the small sample size, and the fact that the "controls" were necessarily (due lack of other control GPS information from the IPU) simply located in similar areas immediately adjacent to the treatments.

Conclusions and Lessons Learned

The analyses, like those for the cover data, demonstrated that there was no systematic bias in the design. The data may be used as a baseline for impact evaluation.

Three significant challenges were addressed with different levels of success, while one is ongoing:

(1) Limited capacity for data collection using standard methods. This was successfully addressed in cooperation with very committed Mongolian Field crews, supported by USDA training and direct support for soil characterization.

(2) Poor quality cage materials. This resulted in the loss of the early baseline data from Phase I areas. It was successfully addressed in Phase II, with some exceptions.

(3) Limited capacity for data management. This limitation was due to a combination of factors including limited experience with databases and data management, and language. It was addressed through extensive interactions with and input from the USDA technical support team. It is an issue that will likely continue to need capacity training and support in the future.

(4) Limited knowledge about when treatments were effectively imposed. This is necessary to determine whether or not the timing of baseline data collection was appropriate, and to adjust conclusions accordingly. The baseline data collection does at least demonstrate that there were no statistically significant treatment *effects* at the time of baseline data collection. We are cooperating with IPA to generate more quantitative and reliable information.